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A STUDY OF THE CHANGE IN DILUTION AND VISCOSITY of AUTOMOBILE CRANK-CASE OIL

A Thesis Submitted to
The Faculty of the Towne Scientific School
of
THE UNIVERSITY OF PENNSYLVANIA
for the
Degree of Bachelor of Science
in
MECHANICAL ENGINEERING

by
O. C. Cresson
M. I. DeCou

June 1926

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CHAPTER I

OBJECT

The object of this Thesis was to determine first, the variation in the percentage of dilution due to gasoline in the lubricating oil in the crank-case of automobile engines as the mileage increases, second, the change in viscosity of that oil with the mileage, and third, the relation between the viscosity and the dilution of the oil.

IMPORTANCE OF THE INVESTIGATION

The average automobile owner does not appreciate the importance of the lubricating system. He does not realize to what extent the life of the car is dependent on the proper lubrication of the moving parts. The importance of this fact is magnified when we consider that the largest percent of the expense of running a car is the overhead and depreciation.

He cannot expect the oil in the cranh-case to maintain its lubricating properties indefinitely, for in every car, no matter how well constructed, there is a certain ammount of leakage of fuel into the crank-case. This investigation determined to what extent this diluent effects the lubricating

properties of the oil, and also at what point the diluted oil becomes no longer fit for lubricating. With definite information as to the conditions under which the lubricant becomes no longer effective it will be possible to change the oil at frequent enough intervals that at no time the moving parts will be in danger due to inadequate lubrication on account of the breaking down of the lubricating film.

The subject of the dilution and viscosity of crankcase oil has been under consideration for comparatively a short time. There were available only two reliable and complete investigations on the subject. These were both recorded in the "Journal of the Society of Automotive Engineers." The first of these experiments was in the issue of February 1924 and the results given in a series of curves as shown by curves 1 and 2 page 6. Curve 1 shows the relation between the dilution in percent and the number of miles the lubricant has been used. Four different fuels were used and it was found that each one had a different effect on the dilution. The general characteristic of these curves is the same, the dilution increasing rapidly at first up to a certain point, and then the further increase is comparatively slow. These tests were carried up to four hundred miles.

Curve 2 page 6 shows the relation between the viscosity Saybolt at one hundred degrees Fahrenheit against crank-case dilution in percent.

In the July issue of the above magazine a report is given in which a study of an engine was made over a period of twelve hours. Curve 3 page 7 shows the results of the dilution test over this period. The viscosity Saybolt is plotted against time of run and the result shown in curve 4 page 7.

They have also made a study of the variation in the flash point with the number of hours run. The readings were taken at the end of the first, third and twelfth hours.

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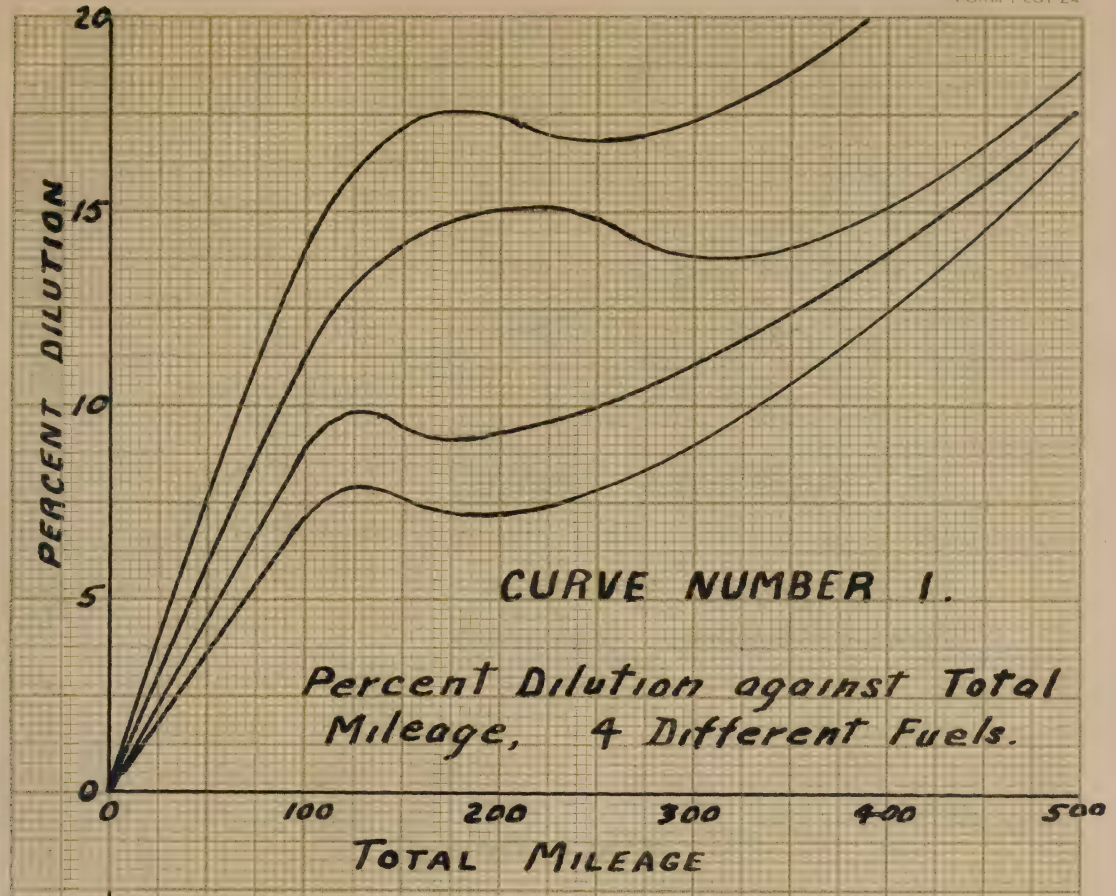
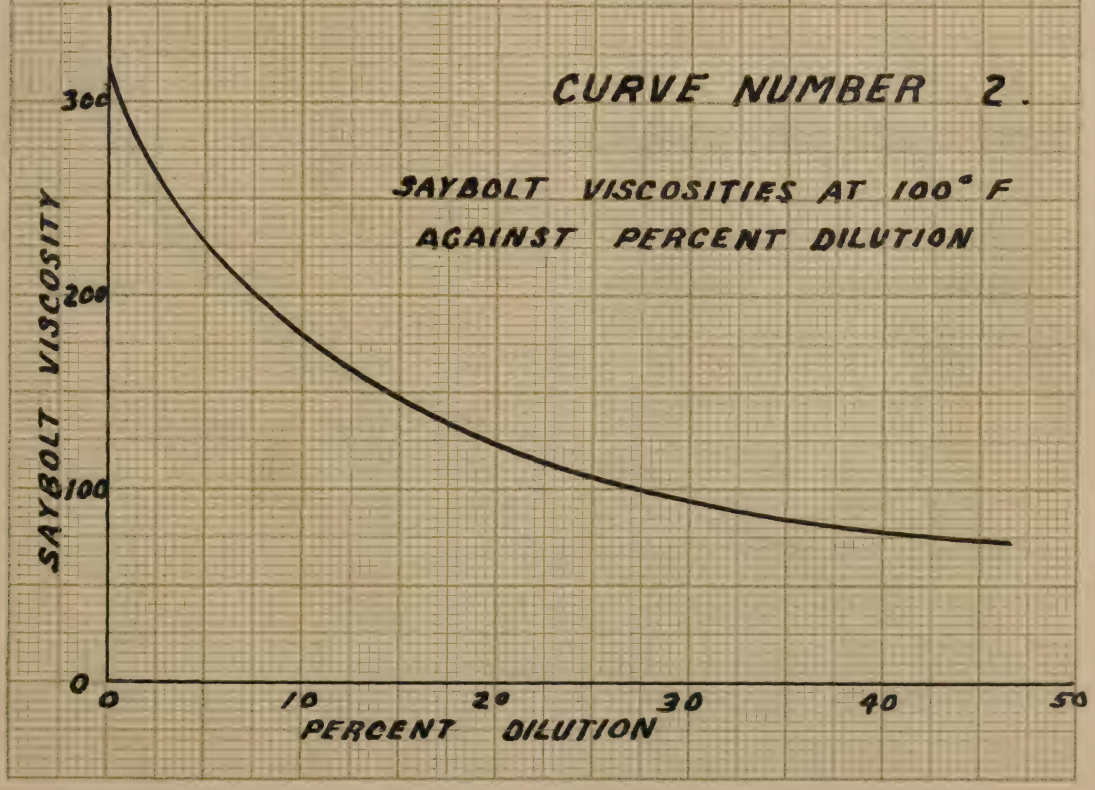


CURVE NUMBER 1.

Percent Dilution against Total Mileage, 4 Different Fuels.



CURVE NUMBER 2.

SAYBOLT VISCOSITIES AT 100° F AGAINST PERCENT DILUTION

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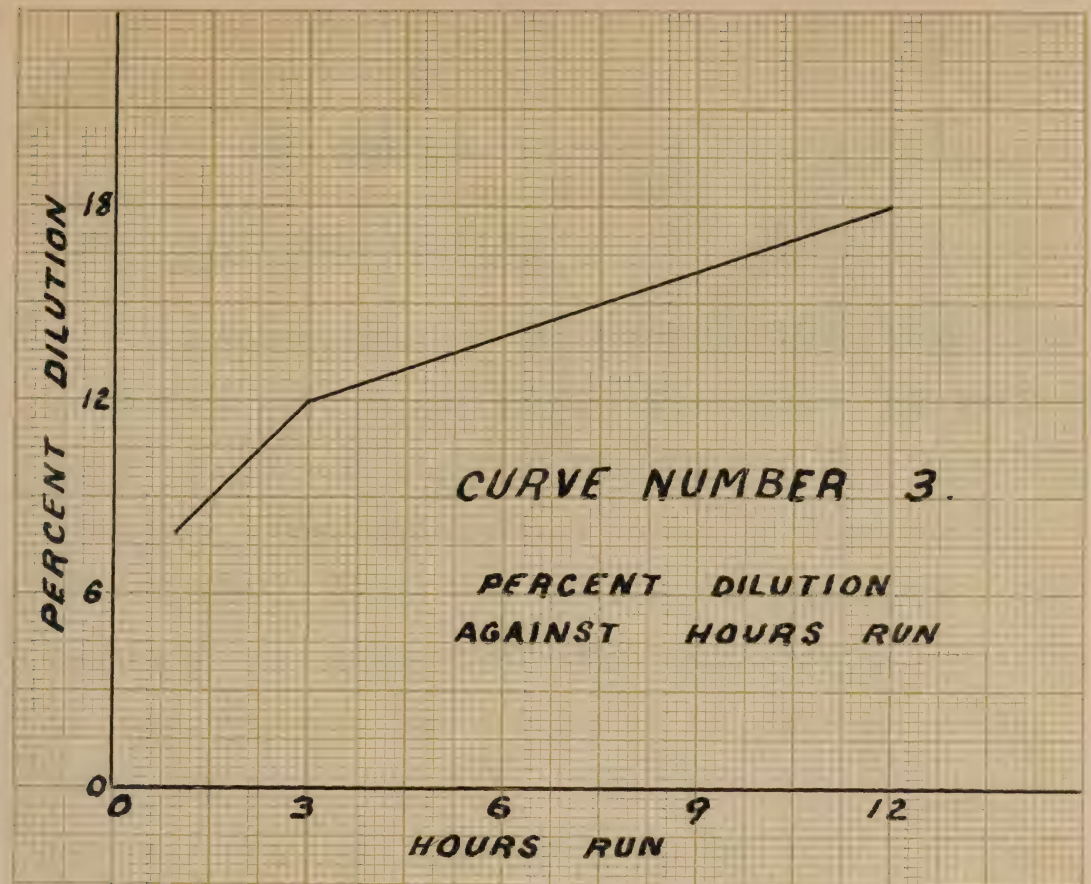
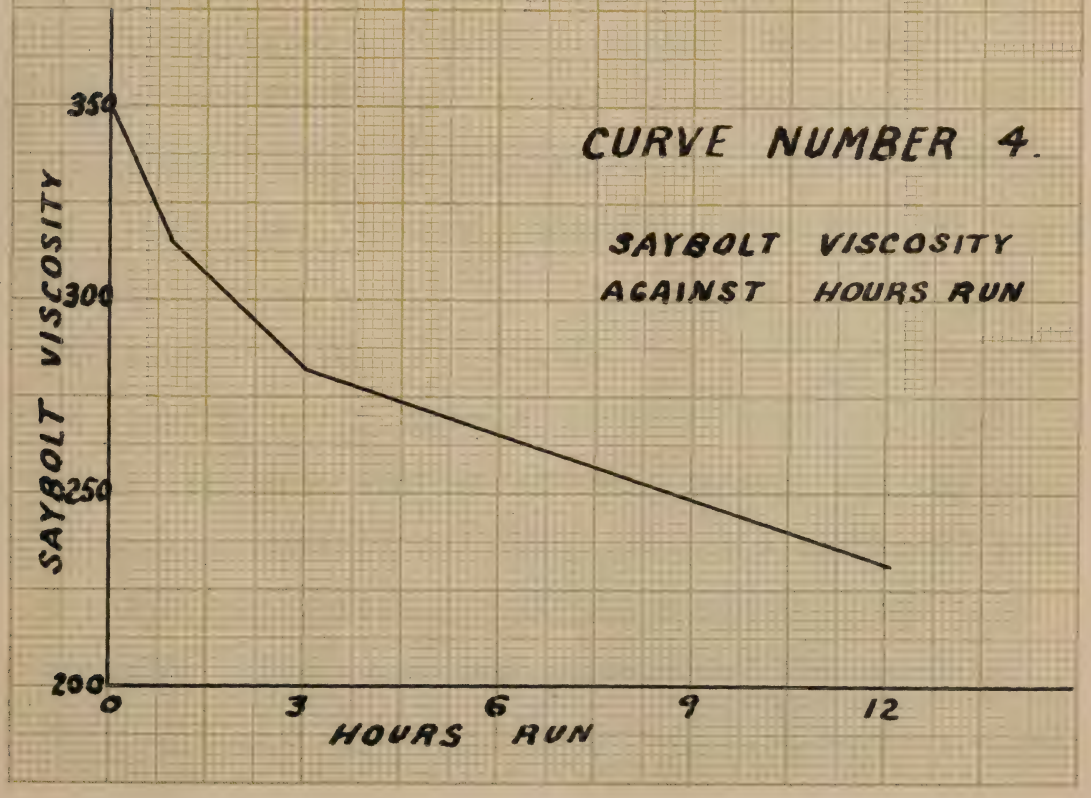


CURVE NUMBER 3.

PERCENT DILUTION AGAINST HOURS RUN



CURVE NUMBER 4.

SAYBOLT VISCOSITY AGAINST HOURS RUN

CHAPTER II

DESCRIPTION OF APPARATUS

The viscosities of the specimens were taken with a standard Saybolt Universal Viscosimeter. The meter is shown on plate 3, page 12, and consists of a cylindrical container approximately nine inches in diameter and nine inches high which is mounted on three legs. Concentrically mounted within this container is a smaller cylinder which has an orifice at the bottom, opening below the outer container. This inner cylinder has a capacity of slightly over 60 c.c. and into this the oil which is to be tested is placed. The outer container is filled with oil and this is used as a bath to afford a means of regulating the temperature of the oil under test. Directly under the bath is a gas burner in the form of a ring which is used to heat the bath. Means are provided for heating the oil by steam or by an electric coil. However, in these tests the gas burner was used exclusively for heating, and the pipe which is furnished for using steam was connected to a cold water outlet by a rubber hose. Thus the bath could be cooled when the temperature went above the desired point. A special flask was furnished which is

accurately marked at the 60 c.c. point.

To determine the viscosity of a specimen it was heated to the desired temperature, poured into the inner cylinder and allowed to remain until its temperature was approximately constant. Then the orifice at the bottom was opened and the oil allowed to flow into the flask. The time interval for 60 c.c. to flow into the flask was accurately determined and recorded. This time interval is termed the viscosity Saybolt and is measured in seconds.

The dilution apparatus is shown in plate 4, page 12, and operates on the principle of fractional distillation. It consists of a glass retort A with a capacity of 200 c.c. A cylinder B which is water cooled, and a capillary funnel C. One hundred cubic centimeters of the specimen to be tested is placed in the retort and this is heated by means of the electric coils D and the gasoline is driven off, passing into the condenser. Here it is condensed and falls into the capillary funnel. The gasoline passes freely through the capillary tube into the graduate, but the oil will pass through this tube only very slowly. Hence, as soon as the gasoline is driven off and the oil begins to come over a head appears above

the capillary tube. The amount of gasoline in the graduate at this time in cubic centimeters gives the percent of dilution of the specimen directly.

PLATE NUMBER 1.

PLATE NUMBER 2.

PLATE NUMBER 3.

PLATE NUMBER 4.

CHAPTER III

PREPARATION FOR TEST.

The first phase in preparation for this experiment was to get all of the available information from previous investigations of this subject. After a thorough search for existing literature on this topic it was found that there is very little specific information to be located. The most informative of this material is condensed in previous history chapter I.

The next phase in the preparation was to set up the apparatus previously described, and in the case of the dilution meter to read up on its operation and to get a clear conception of the principles involved. It might be mentioned here that in the case of the viscosimeter the standard temperatures for viscosities are at one hundred degrees Fahrenheit, one hundred and thirty, and two hundred and ten. The one hundred degree temperature was chosen because at higher temperatures there is danger of driving off some of the diluent.

Having become acquainted with the theory of operation of the apparatus it was next necessary to

become proficient at operating the same in order to obtain accurate results. In order to do this numerous runs on medium engine oil were made. One by one the various causes of error were eliminated or decreased. It might be advisable at this point to mention a few of the more important of these causes of error. It is necessary to have the viscosimeter free of any foreign matter which might partially obstruct the orifice, such as dust, lint, hair, or carbon. Also it is advisable between each run to carefully wipe the orifice in order to prevent the formation of a film of thick or gummy oil on its walls. Lastly, and probably the most important factor is the temperature. It is not only necessary to have the specimen oil at the given temperature, but to keep these conditions during the run, and to keep the oil uniform throughout.

In order to become acquainted with the operation of the dilution meter numerous runs were performed on made-up samples of oil and gasoline of known proportions. Since this meter operates on the principle of fractional distillation and the percentage dilution is determined by the rate of flow through the capillary tube, it is necessary to have the rate of distillation constant throughout all of the runs. In order to do

this the retort had to be adjusted to the correct height above the heating coils. A thorough cleaning of the entire apparatus was imperative between each run in order to eliminate the possibility of oil obstructing the capillary tube at the beginning of distillation.

After attaining proficiency in the operation of the dilution meter a series of tests were performed on made-up samples the dilution of which increased in consecutive intergers from one to ten percent. The results of these tests are shown in table 1,page 18, and curve 5, page 19.

ACTUAL CONDUCT OF TEST.

For the purpose of this test two Pierce Arrow series eighty cars were selected, which were operated under average conditions, and kept in very good running order. They were 1925 standard stock cars and had run approximately 5000 miles previous to the test. The oil was changed every 1000 miles and no oil was added between these changes. The specimens obtained were reliable and the data recorded accurately. The specimens were taken in test tubes which conveniently held 100 c.c. First a specimen of the original oil was taken from the stock before it was put into the crank-case. Then after the car had been driven from ten to twenty-five miles the first sample was drained from the crank-case. Each specimen was taken from the motor while the oil was well mixed, before it had an opportunity to settle. As the total mileage increased the interval of mileage between each succesive specimen was increased, because the increment of change of dilution and viscosity is greater at first than after the oil has been used for some length of time. The mileage interval between the last two specimens varied from 150 to 200 miles, making the total mileage on the oil approximately 500 miles.

The next and final step in the actual conduct of the test was to determine the dilutions and viscosities of the specimens. The actual running of the specimens through the meter was a comparatively simple task after so complete a preparation and study of the apparatus. The viscosity had to be run first since this does not change the dilution, while the dilution test materially changes the viscosity. The viscosity of each specimen was found twice and the mean value determined. The values thus obtained are recorded in table 2, page 20, and table 4, page 25. Curves 6, and 9 are the viscosities Saybolt in seconds against the total mileage on the oil.

The final operation in the actual conduct of the test was to determine the dilution of each specimen and record these as shown on table 3, page 22, and table 5, page 27. Curve 7, page 23, and curve 10, page 28 were determined dy plotting dilution against mileage.

CHAPTER IV

DATA, RESULTS, AND CURVES

TABLE NUMBER 1.

RESULTS OF PRELIMINARY WORK ON DILUTION METER

Sample Number	Actual Percent Dilution	Percent Dilution As Read	Sample Number	Actual Percent Dilution	Percent Dilution As Read
1	1.0	0.9	11	1.0	0.8
2	2.0	1.7	12	2.0	1.8
3	3.0	2.7	13	3.0	2.9
4	4.0	3.5	14	4.0	3.6
5	5.0	4.8	15	5.0	4.5
6	6.0	5.1	16	6.0	5.6
7	7.0	6.2	17	7.0	5.9
8	8.0	7.3	18	8.0	7.1
9	9.0	8.0	19	9.0	8.2
10	10.0	8.9	20	10.0	9.1

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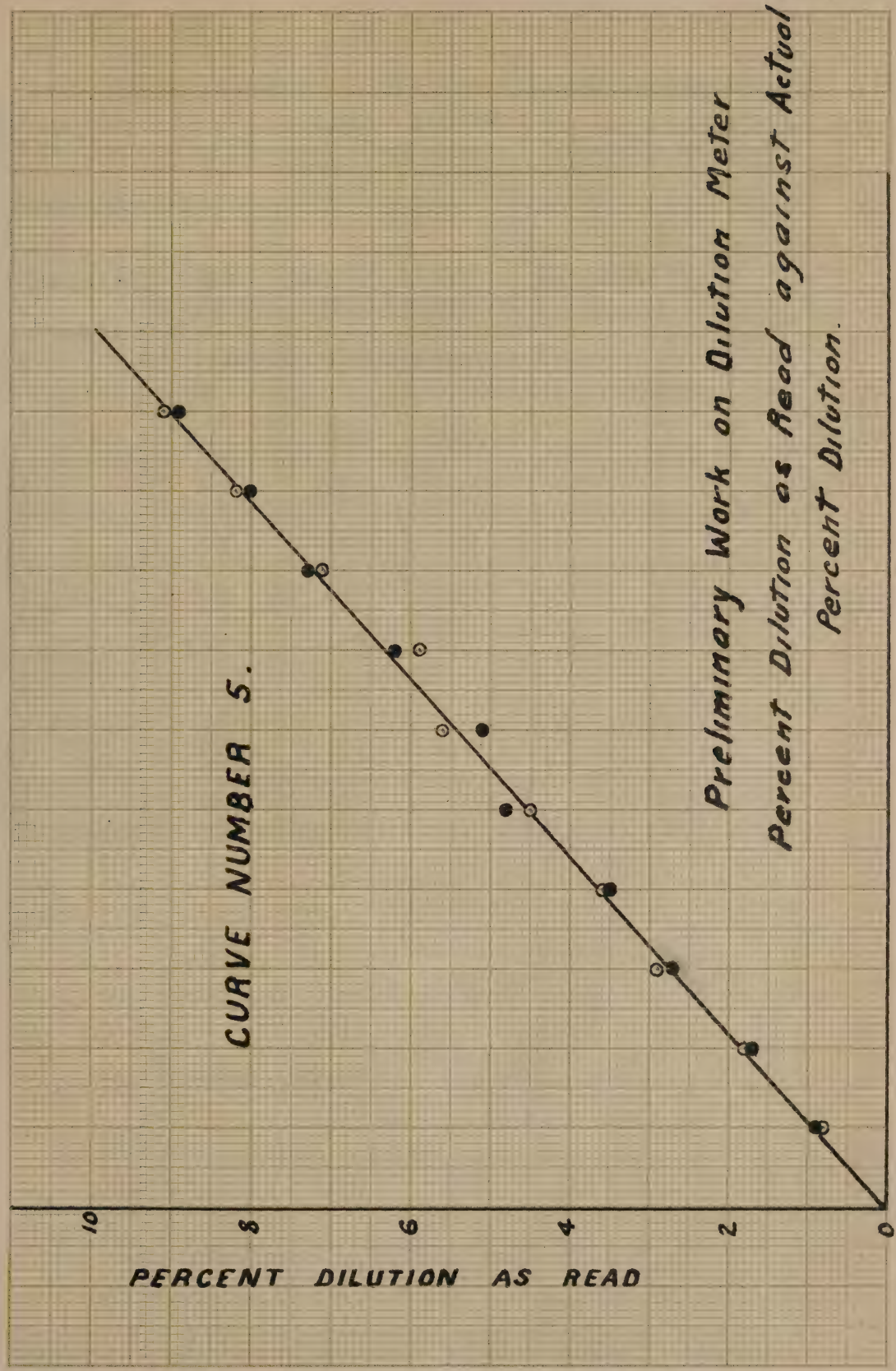

TABLE NUMBER 2.					
CAR A VISCOSITIES					
Sample Number	FIRST Saybolt Vis. in Seconds	SECOND Saybolt Vis. in Seconds	MEAN Saybolt Vis. in Seconds	Mileage of each Sample	Total Mileage
1	311	296	303.5	0	0
2	257	253	255	28	28
3	208	210	209	42	70
4	183	188	185.5	71	141
5	159	165	162	74	215
6	148	147	147.5	92	307
7	117	114	115.5	159	466
8	106	106	106	129	595

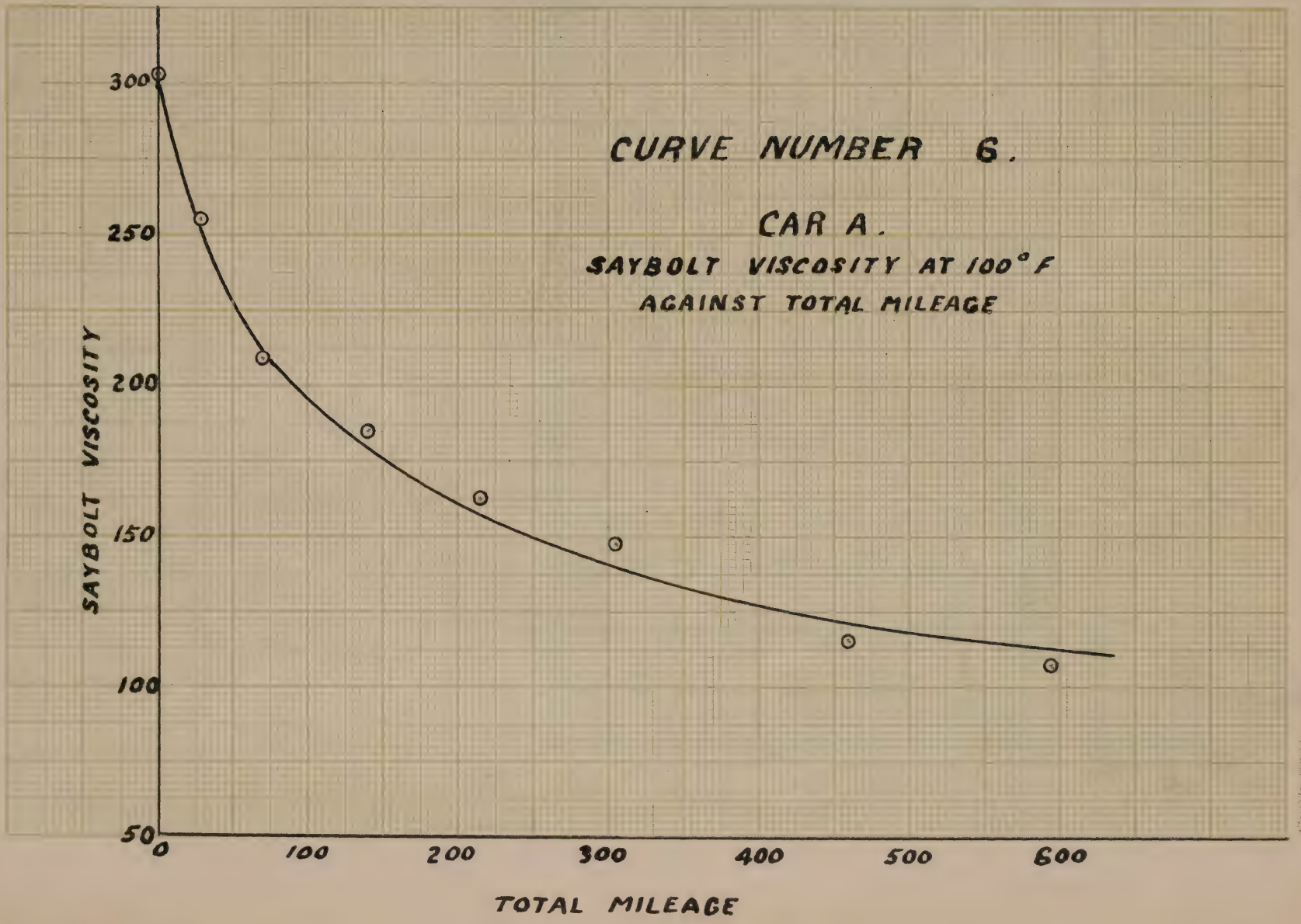

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TABLE NUMBER 3.

CAR A DILUTIONS.

Sample Number	Number of c.c.	Dilution As Read in c.c.	Correct Percent Dilution	Mileage of each Sample	Total Mileage
1	82	1.1	1.3	0	0
2	95	2.9	3.1	28	28
3	91	4.2	4.6	42	70
4	100	5.9	5.9	71	141
5	100	8.3	8.3	74	215
6	96	9.5	9.9	92	307
7	90	9.6	10.7	159	466
8	100	10.6	10.6	129	595

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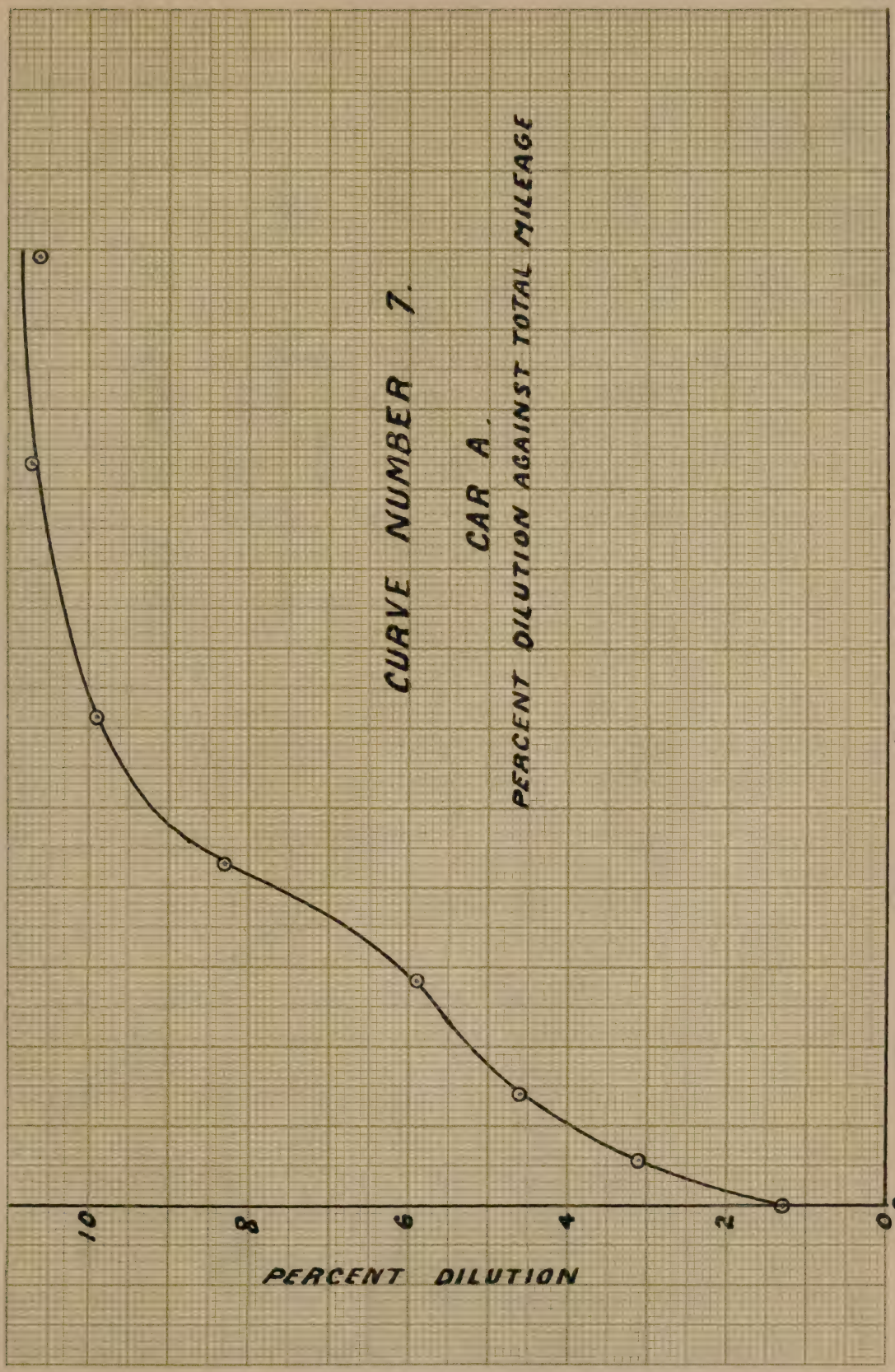

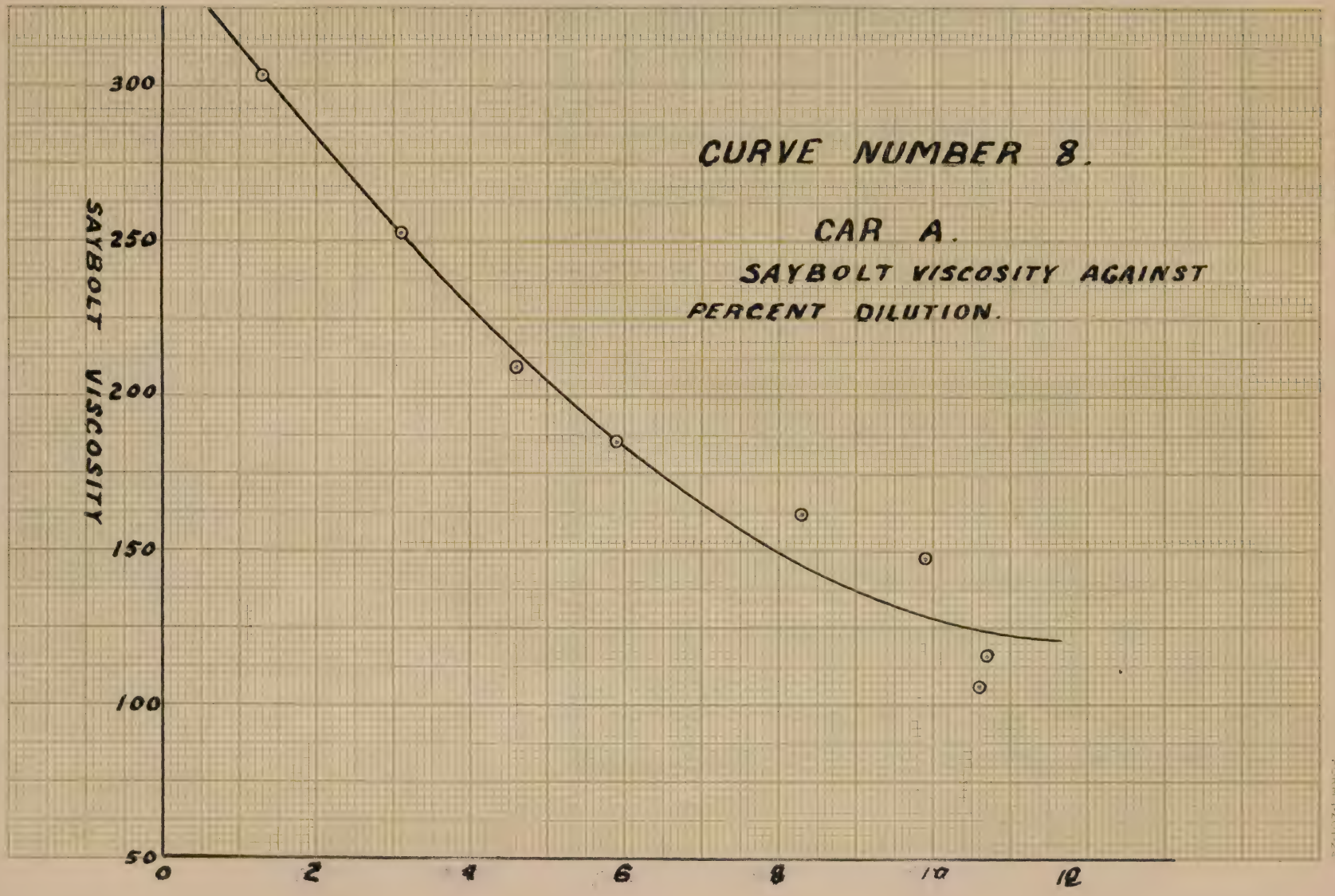
CURVE NUMBER 8.
CAR A.
SAYBOLT VISCOSITY AGAINST
PERCENT DILUTION.
SAYBOLT VISCOSITY
300
250
200
150
100
50
0
2
4
6
8
10
12
PERCENT DILUTION

TABLE NUMBER 4.

CAR B VISCOSITIES.

Sample Number	FIRST Saybolt Vis. in Seconds	SECOND Saybolt Vis. in Seconds	MEAN Saybolt Vis. in Seconds	Mileage of each Sample	Total Mileage
1	311	296	303.5	0	0
2	245	248	246.5	13	13
3	214	219	216.5	31	44
4	178	179	178.5	80	124
5	159	158	158.5	65	189
6	148	163	155.5	72	261
7	134	135	134.5	171	432

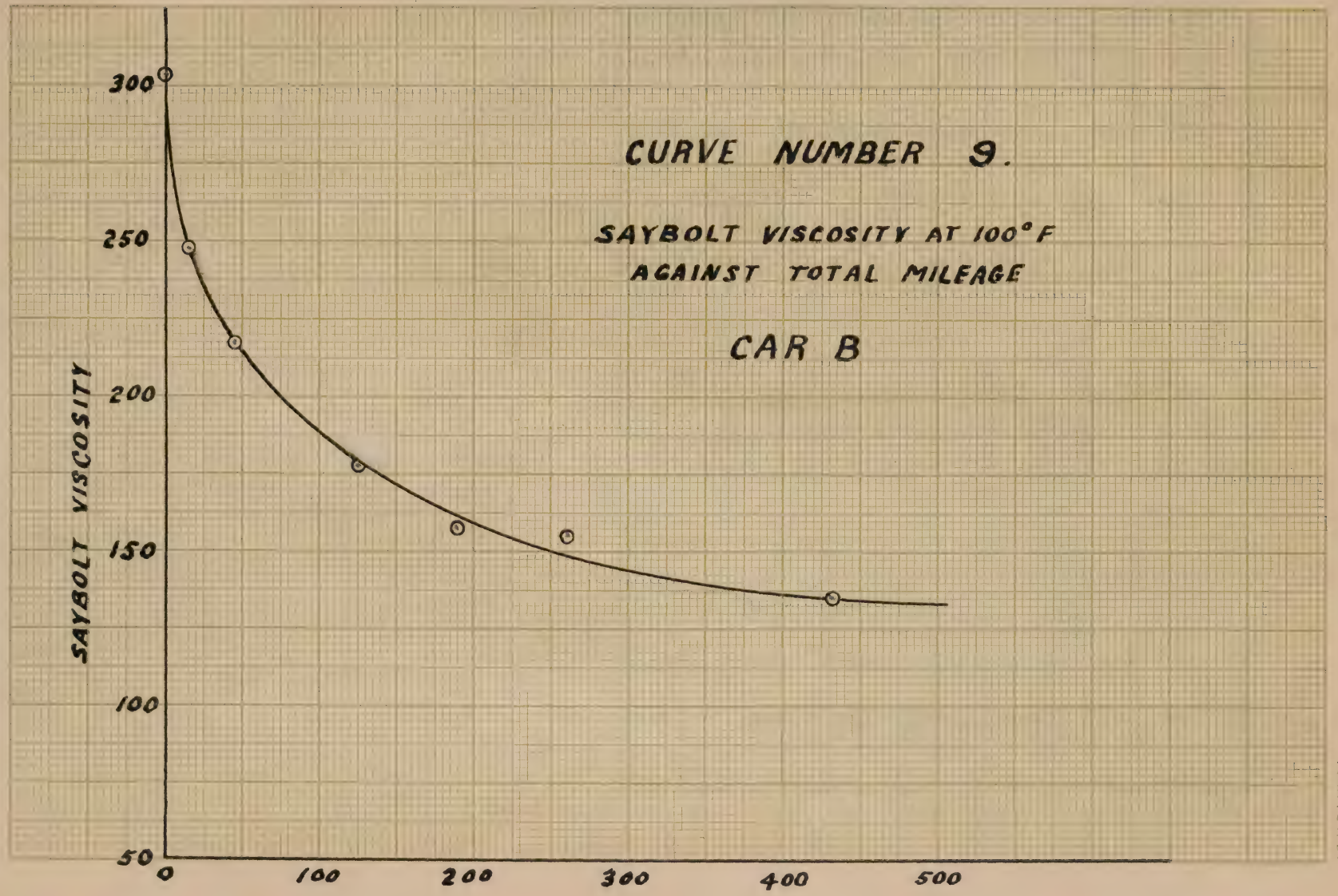

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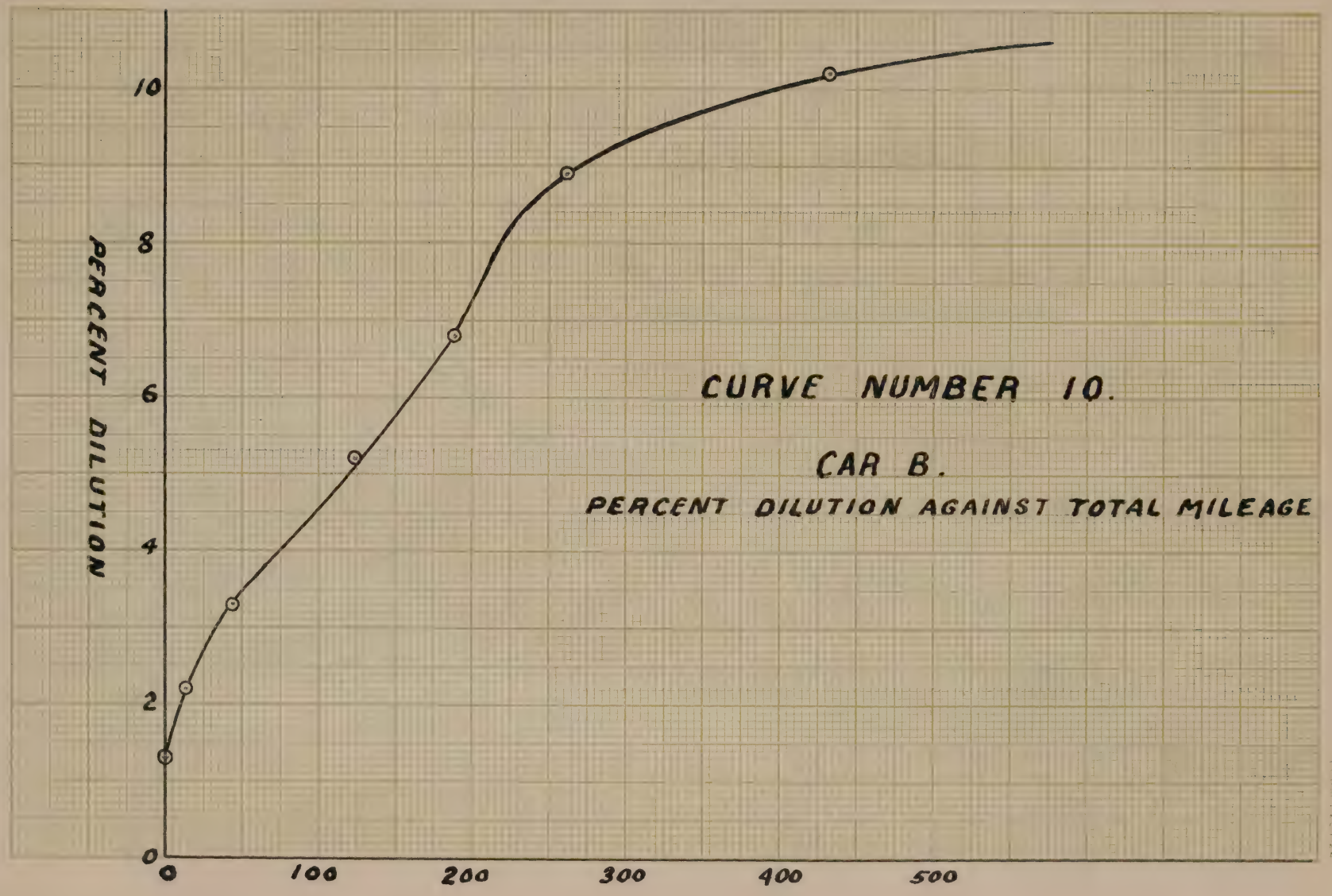
TABLE NUMBER 5.					
CAR B DILUTIONS					
Sample Number	Number of c.c.	Dilution As Read in c.c.	Correct percent Dilution	Mileage of each Sample	Total Mileage
1	82	1.1	1.3	0	0
2	90	2.0	2.2	13	13
3	90	3.0	3.3	31	44
4	90	4.7	5.2	80	124
5	100	6.8	6.8	65	189
6	90	8.0	8.9	72	261
7	100	10.2	10.2	171	432



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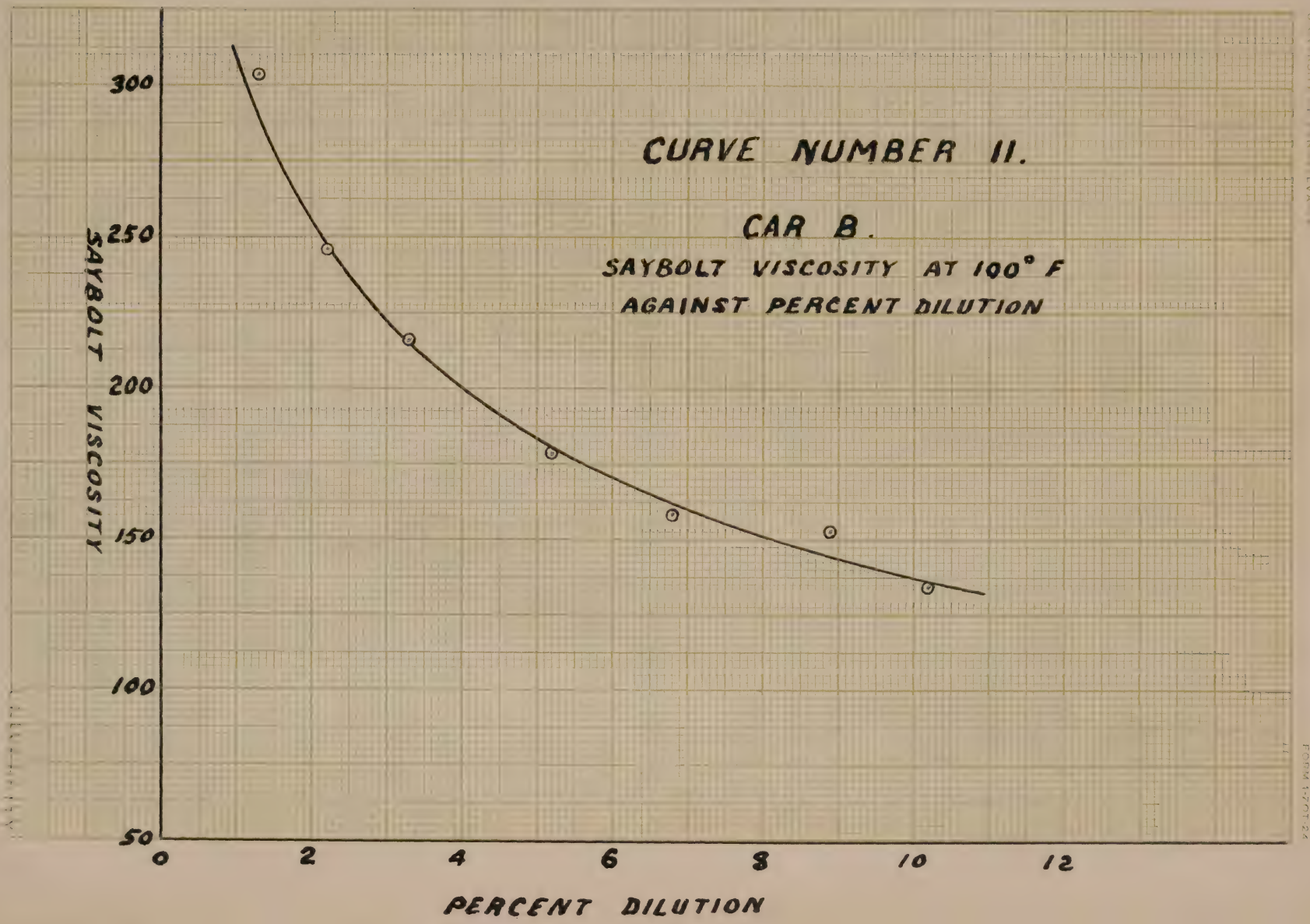
CURVE NUMBER II.
CAR B.
SAYBOLT VISCOSITY AT 100° F
AGAINST PERCENT DILUTION
SAYBOLT VISCOSITY
300
250
200
150
100
50
0
2
4
6
8
10
12
PERCENT DILUTION

CHAPTER V

ACCURACY OF TEST, METHODS, AND RESULTS.

The first consideration in obtaining accuracy in the tests is to record carefully the mileage when each specimen is drawn, using, if possible, some check method to assure no errors. The mileage covered since the preceding specimen was drawn off and the speedometer total were both recorded on the tube containing the specimen. In this manner a check on the first stage was obtained.

For testing the viscosity a Saybolt Universal Viscosimeter was used. Careful work on this meter should check to within not more than five percent error, and usually to within two percent.

In the case of the dilution meter it is only claimed to be correct within two cubic centimeters. Therefore work on this apparatus is not as accurate as that on the viscosimeter. However, after numerous preliminary runs, results were obtained which were within one cubic centimeter, or not greater than ten percent error. The accuracy of both the viscosimeter and the dilution meter depends mainly on the ability of the operator. Because the personal element played such an important part, it was necessary to spend

most of the time in becoming proficient in handling the apparatus.

The fact that the viscosities checked closely, and that the points for both the viscosities and the dilutions lie very near to the smooth curves is evidence of the accuracy of the results.

CONCLUSIONS TO BE DRAWN FROM THE RESULTS.

The results obtained from these investigations point to the fact that the lubricating qualities of the oil are materially reduced with use. This deterioration of the oil is very rapid during the first part of the run. As the run advances there is a tendency to approach constant conditions of dilution and viscosity.

The general characteristics of these curves are the same for all cars, but the condition of the motor especially as regards to the piston rings and cylinder walls.has a marked effect in determining the amount of dilution,which in turn effects the viscosity.

With the general characteristics of the curves as determined by these investigations it would be possible , knowing a point or two on the curve for

any specific car, to approximate the particular curves for that car.

COMPARISON OF RESULTS WITH PREVIOUS INVESTIGATIONS

The curves resulting from these tests have the same general characteristics as the two sets of results which were available from previous investigations. The study, the results of which are shown by the dilution curves 1, page 6 have a peculiar inflection which is noticeable in the dilution curves of this investigation.

COMPLETENESS OF INVESTIGATION AND RECOMMENDATIONS FOR FURTHER RESEARCH.

This report is rather complete from the viewpoint of dilution and viscosity, in the sense that it is a careful investigation of these variables under average running conditions for these cars. Further research is recommended by performing tests on crank-case oil to determine the variation in flash point, burning point, specific gravity and cold test. Another field for investigation is the determination of the danger poimt on each of these curves.

CHAPTER VI

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